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BIOLOGICAL EVALUATION OF NURSERY PESTS AT JOSHUA TREE NATIONAL MONUMENT

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ABSTRACT

Several insect species were found on desert plants grown in the nursery at the Joshua Tree National Monument. Biotic plant diseases were not observed, but ozone damage was present. Management alternatives are presented and discussed -- monitoring-no action, cultural and biological control, chemical treatment (topical and systemic), and use of biologicals and other treatments.

INTRODUCTION

Because an integrated pest management plan is being developed for Joshua Tree National Monument, the National Park Service requested an evaluation of pests found in the nursery located at the monument headquarters. On October 29, 1987, John Kliejunas, plant pathologist, and I met with Jenness Coffee, Heidi Haid, and Melodie Spoo of the staff at Joshua Tree National Monument. A tour of the nursery was conducted and insect specimens previously collected were examined.

OBSERVATIONS

The nursery is located on a small tract of ground near the park headquarters and consists of a shadehouse, greenhouse, and outplantings of Opuntias (Fig. 1). This location is within the Joshua Tree Scrub Formation at the edge of the Mojave Desert in southern California (Vasek and Barbour 1977). Most of the plants are grown in sections of PVC pipe (3 feet by 6 inches diameter) after being initiated in the greenhouse. These sections are filled with a porous potting material not unlike a bonsai mix. Water is provided by an overhead drip-irrigation system. There is one plant per tube, and each plant can develop the substantial root system necessary for outplanting survival in the demanding climate of Joshua Tree National Monument.

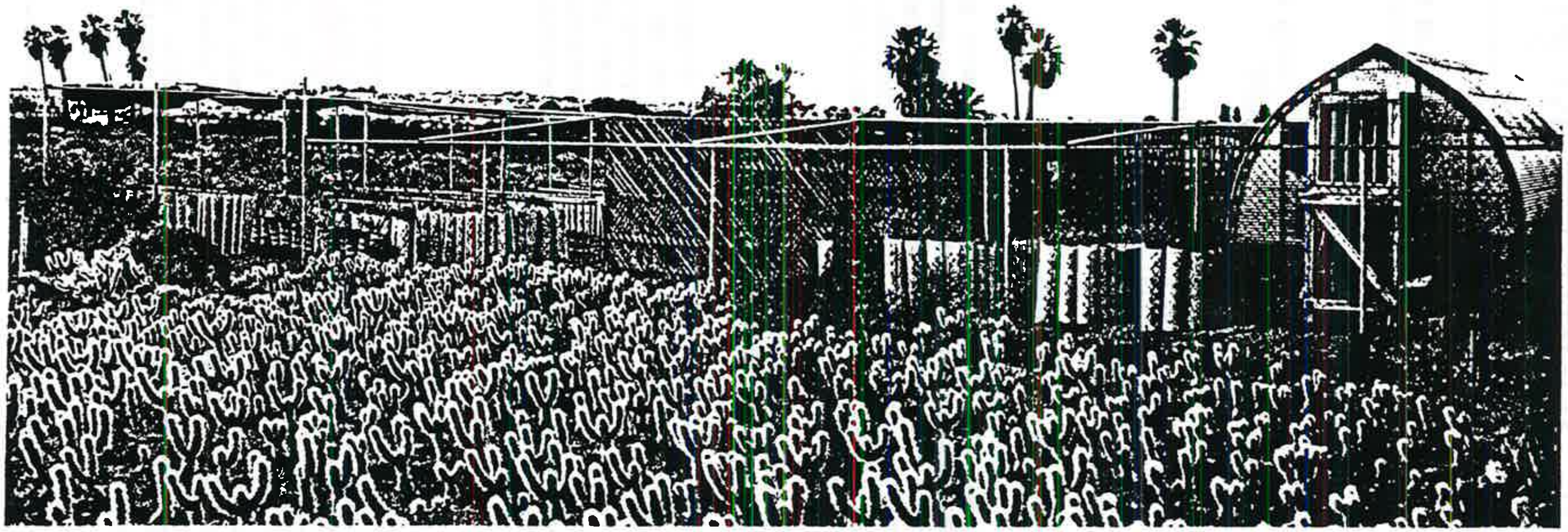

Figure 1. Greenhouse and shadehouse at Joshua Tree National Monument. Opuntias in the foreground; the town of Twentynine Palms in the left background.

Some plants in the nursery, or proposed for the nursery (Table I), are grown to provide ground cover for sites such as abandoned roads and trails. Others are grown for the establishment of plots for monitoring air pollution. The program of site rehabilitation is to continue for at least five years and nursery production will continue for at least this period of time.

Several insect species were found on nursery plants, but numbers were not abundant in late October. These species were among the specimens previously collected by park personnel. Defoliation was noticeable on coyote melon and Jimson weed. Patches of willow stem had numerous oviposition scars located under a white, woolly material obviously spun by an insect that was no longer present. Specimens collected, along with those previously collected, were submitted to Laboratory Services, California Department of Food and Agriculture, for identification. The termites were submitted to Dr. M. J. Haverty at the Pacific Southwest Forest Experiment Station, Berkeley.

RESULTS

Several of the insect species found (Table II) are commonly considered agricultural pests. They probably could be found in any local garden and are likely to occur at the nursery every year. General information on these from standard reference works is given in the appendix.

In addition to the threelined potato beetle, *Lema trilineata* (Olivier), the striped datura beetle, *L. nigrovittata* Guerin, can be expected in the nursery because Jimson weed is its native host. Similarly, the weevil larvae found, *Trichobaris* sp., could be either the potato stalk borer, *T. trinotata* (Say), or the Jimpson weed borer, *T. mucorea* (Lec.). In addition to the cabbage looper, *Trichoplus ni* (Hubner) larvae of other noctuid moths can be expected to cause defoliation on nursery plants. Members of the Pieridae (sulfur butterflies) such as the imported cabbageworm, *Pieris rapae* (L.), should occur also.

Planthoppers, such as *Ormenis* sp., are a concern because they can transmit viral diseases. The white woolly material associated with the oviposition scars of the planthoppers appeared very similar to such material associated with some mealybugs, but no insects were found within the masses.

If the eggs from senna are those of Reduviids, similar clusters should not be disturbed because these insects are good predators of some of the pests listed in Table II. Although the characteristics and habitat of the worker termites indicated *Gnathamitermes perplexus*, the identification of termites is uncertain unless based upon members of the soldier cast and future collections should include soldiers. However, there is a high probability that the termites were indeed *G. perplexus*.

The only aphid collected was the cotton or melon aphid, *Aphis gossypii* Grover. Aphids are quite common in nurseries and other species can be expected to occur. Searching and handpicking aphids from the host plant is the best means of collection for producing the host data that are often needed for identifying specimens. Notes on the natural colors of the living insects are helpful for making identifications and they are also useful for future recognition in the field (Martin 1977).

Table I. NATIVE PLANTS PROPOGATED OR PROPOSED FOR PROPOGATION, JOSHUA TREE NATIONAL MONUMENT

Bladderpod	Isomeris arborea
Blackbrush	Coleogyne ramosissima
Brittle-bush	Encelia farinosa
Burr bush	Franseria dumosa
California joint fir	Ephedra californicus
Cheese-bush	Hymenodea salsola
Chia	Salvia columbaria
Chuparosa	Beleperone californica
Creosote bush	Larrea tridentata
Coyote melon, palmate-leaved gourd	Cucurbita palmata
Desert almond	Prunus fasciculata
Desert lavender	Hyptis emoryi
Desert squaw-bush	Rhus trilobata
Goat-nut jojoba	Simmondsia californica
Jimson weed	Datura meteloides
Paper-bag bush, bladder sage	Salazaria mexicana
Purple bush	Halliphytum hallii
Senna, desert Cassia	Cassia armata
White ratany	Krameria grayi
Beavertail cactus	Opuntia basilaris
Cottontop cactus	Echinocactus polycephalus
Pencil cholla	Opuntia ramosissima
Silver cholla	Opuntia echinocarpa
Teddy-bear cholla, jumping cholla	Opuntia bigelovii
Cat's claw acacia	Acacia greggis
Desert willow	Chilopsis linearis
Desert ironwood	Olneya tesota
Juniper	Juniperus californica
Palo verde	Cercidium floridium
Smoke tree	Dalea (Parosela) spinosa
Joshua tree	Yucca brevifolia
Mohave yucca	Yucca schidigera
Galleta grass	Hilaria rigida
Indian ricegrass	Oryzopsis hymenoides

TABLE II. INSECTS IDENTIFIED FROM THE NURSERY, JOSHUA TREE NATIONAL MONUMENT

		Determiner:
Collection:	adult	
Host:	*Datura meteloides*, Jimson weed	
Insect:	*Lema trilineata* (Olivier)	T.N. Seeno[1]
	Threelined potato beetle	
Collection:	larvae	
Host:	*Datura meteloides*, Jimson weed	
Insect:	*Trichobaris* sp.	T.N. Seeno
	A stem-boring weevil	
Collection:	eggs in stem tissue	
Host:	*Salix gooddingii*, willow	
Insect:	prob. *Ormenis* sp. (Flatidae)	R.J. Gill[1]
Collection:	egg cluster on vegetation	
Host:	*Cassia armata*, senna or desert cassia	
Insect:	prob. Reduviidae	A.R. Hardy[1]
Collection:	apterous forms	
Hosts:	*Cucurbita palmata*, coyote melon	
	Salazaria mexicana, bladder sage	
Insect:	*Aphis gossypii* Grover	Tokuwo Kono[1]
	cotton or melon aphid	
Collection:	larvae	
Host:	*Cucurbita palmata*, coyote melon	
Insect:	*Trichoplusia ni* (Hubner)	T.D. Eichlin[1]
	cabbage looper	
Collection:	worker cast	
Host:	unknown	
Insect:	*Gnathamitermes* ?*perplexus* (Banks)	M.J. Haverty[2]

1. California Dept. of Food and Agriculture, Division of Plant Industry, Laboratory Services, Sacramento.
2. Pacific Southwest Forest & Range Experiment Station, Berkeley, Ca.

It is often convenient to remove the infested plant part and preserve it in alcohol along with the aphids. All stages present are more likely to be collected in this manner. The infested part may also be placed in a plastic bag that is subjected to cool storage for a few days prior to perservation. This method often yields additional winged forms, or late in the season it may provide sexuales. These aid greatly in identifying to the species level (Martin 1977).

The cabbage looper is a member of the Noctuidae, the largest family of the Lepidoptera. Other members of this diverse group will be found with systematic monitoring procedures. The cabbage looper larvae, which is the damaging stage, have only two middle pairs of abdominal legs and propel themselves in a series of "looping" movements, thus the common name looper. However, they are not geometrid larvae, the true loopers.

No scale insects were seen, but it seems unlikely that they will always be absent from the nursery. If scales do occur, hatching of the eggs and the appearance of the crawler stage should be detailed because this is the period of the life cycle most susceptible to control by contact insecticides.

No biotic diseases were observed, but symptoms of ozone injury were present. The growing conditions and watering system at Joshua Tree National Monument do not preclude problems with plant pathogens, but are not as favorable to pathogens as the regimen usually encountered in typical commercial nurseries.

DISCUSSION

Pest damage prevention is the best nursery management practice. This includes an effective pest information program whereby all nursery personnel will become aware of potential pest problems and will be able to engage in early pest detection, and rapid diagnosis and damage assessment. Standardized systematic quarantine measures should be employed, such as preventing the transport of contaminated plants, soil, water, and equipment into the nursery (Cordell 1979).

Unfortunately, exclusion of most insects is not practical at Joshua Tree, and the regulation of the physical environment is possible only within narrow limits centered on the natural environment of ambient temperature and light. Local plant stock is being used and resistant varieties are beyond the scope of the project. Control by cultural and sanitary procedures seem unlikely because the nursery is well maintained and surrounding weeds kept back. Biological control enhancement is a possibility, but the probability of a dusty environment is a disadvantage in this respect. A frequently dusty environment often hinders parasites more than the prey.

Prevention of insect population buildup by scheduled chemical applications can be used before damage occurs when it is nearly certain that the target pest will be encountered. Timing would depend on site-specific life history information that could be tied to environmental data such as degree-day relationships. This information could be gathered, but it would be a time-demanding task for a limited staff and the limited production of the nursery.

This leaves see-and-treat as a better prospect for chemical control than treatment on a regular schedule. Frequent and regular inspections of the nursery stock are required, but this appears to be a process already in place. Careful insect monitoring leads to low dosage rates and precise timing of applications. The size of plant production also lends itself to a see-and-treat approach.

MANAGEMENT ALTERNATIVES

Management will have to decide the intensity of pest management to be maintained and what alternative or combination of alternatives best suit the nursery and planting objectives. Questions to be answered include: How much damage to the plants can be tolerated? If the roots are well developed and the plants are to be soon outplanted, can higher levels of defoliation be tolerated? Should aphids be transported to the field where the plants will not have abundant water to pass on to the aphids? Management will need to establish some guidelines for damage thresholds that, once exceeded, indicate that some form of direct suppression is appropriate. A population threshold indicative of damage and adapted from agriculture, such as 7 aphids per leaf, might be useful, or the nursery staff may establish a threshold based upon their own observations.

1. Monitoring, No Action. If insect populations remain low and management is willing to accept minor amounts of damage, no action other than monitoring would seem appropriate.

2. Cultural. Keeping young plants healthy deters insect attack and losses. Therefore, it is necessary to prevent exposure to factors such as frost damage, nutrient deficiences and toxic chemicals that predispose seedlings to pest problems. For example, vigorous plants usually are able to withstand aphid attack better than those growing poorly, although the rate of reproduction is often greater on the thrifty growing stock.

Maintenance and sanitation will help prevent unacceptable pest population increases. Senescent plant parts should be removed and destroyed, particularly in the autumn. This is especially important with insects such as the Jimson weed borer that overwinter within their hosts.

Gardens with their attractive plant hosts should be kept away from the nursery. Similarly, weeds harbor pests, particularly aphids, and should be cleared from close proximity to the nursery. Some recommendations include not growing potatoes, milkweed and Jimson weed, among others, within 150 ft of greenhouses because they serve as hosts for insect pests (Sorenson 1975). However, at Joshua Tree some of these are the very plants being cultivated.

Plants are well spaced with the current method of cultivation in the plastic pipe. This allows for easier application of chemicals because the plant surfaces, such as the undersides of the leaves, are accessable. Spacing the plants imitates the native habitat of local parasites and predators and they should be well adapted to this environment. Spacing also requires immature

insects to travel greater distances when moving from plant to plant, thus exposing themselves to a greater risk of predation.

Segregating plants by species could also be beneficial. For example, the cabbage looper can accept a wide range of food hosts at late stages of larval development and apparently is not restricted to plants by specific chemicals. However, first instar larvae do not develop on Jimson weed (Soo Hoo, et al. 1984). Early instars would have to develop on coyote melon or another host before larvae could feed on Jimson weed. By separating the Jimson weed well away from other hosts, it is less likely that the larger and more damaging larvae could find their way to the Jimpson weed.

An ample water supply, such as the drip-irrigation system, helps plants to contend with the moisture drain caused by feeding aphids and other sucking insects, and leaf loss in late summer would be less likely from heavy feeding. However, before outplanting, the plants should be hardened by reducing their water supply. Feeding by aphids during this period could be damaging even though tender plant material would be less available, and suppression treatments might be necessary.

Sturdy plants such as the willow can be sprayed with a forceful jet of water to dislodge aphids and other insects. Most flightless insects will not be able to return to the plant after this treatment. The effectiveness of water sprays is improved when soap (1 tb per gal), which makes water "wetter", is added. Repeat sprays as necessary (Moore and Koehler 1979).

At times it might be appropriate to prune plants. For example, insects inside galls or curled leaves present a problem because most sprays do not reach into these spaces. With small plants, sometimes the best control method is to prune off the galled or curled leaves (Moore and Koehler 1979).

3. <u>Biological Control</u>. Predators and parasites of the collected pests are no doubt present in the nursery; the collection of eggs from senna is one example. The identity and life cycles of these should be ascertained in order that any chemical treatments can be manipulated to minimize the impact on these benficial insects.

The population of predators in the nursery could be supplemented by local collections or by purchase from commercial dealers. Local predators could be collected by gently beating desert shrubs and plants over a light-colored cloth laid on the ground or held between the ends of two crossed sticks. Immatures are preferable to adults for the adults might soon stray from the nursery area once released. Park staff doing the collecting would have to learn to recognize the life stages of the desired predators.

Eggs, larvae and adults of parasites and predators, such as lacewings and ladybird beetles, can be purchased from commercial firms. Sources for these can be found in the back of various gardening and horticultural magazines and journals, and extension pamphlets (Hickman 1980, see appendix). Those reared in southern California might be better adapted to the southern desert environment. Significant carryover from one season to another by inundative releases cannot be expected. The presence of alternate hosts and the occurrence of mild winters is helpful.

The nursery population of the green lacewing might be augmented by the use of artificial diets. The larvae of the green lacewing (Chrysopa carnea Steph.) are predacious, but adults feed on honeydew and pollen. About half of Chrysopa species have a similar habit. Certain artificial honeydews can be applied in the field to simulate homopterous honeydew and attract C. carnea adults and increase egg deposition. The effect is to induce earlier larval predation against both insect producers and nonproducers of honeydew (Hagen et al. 1971, 1976). The artificial honeydew can be made from 240 g of Bee Wheast® (Stauffer Chemical Co., Visalia, CA)[3], 290 g sucrose (cane sugar), and 500 ml of water. The diet does not attract ladybird beetles, but they become concentrated in the food-sprayed areas. When coming into contact with the diet the beetles remain and feed (Hagen et al. 1976).

4. Behavior Modifying Chemicals. Pheromones are chemical substances produced by insects and released by one sex to attract or excite the opposite sex for mating. Pheromones of lepidoptera have received a great deal of attention in the recent years and pheromones are now known for several agricultural pests including the cabbage looper. A commercial formulation known as "looplure" can disrupt all facets of pre-mating communication, even when adult densities are high. This pheromone is produced by the female, but another disruptant, "hexalure," is not naturally produced by the insect (Inscoe and Beroza 1976).

Kits using a pheromone for monitoring the cabbage looper are commercially available. Monitoring would be useful in timing chemical treatments if the cabbage looper becomes a major pest in the nursery. One or two larvae per plant could do considerable damage to coyote melon. Sticky traps with or without a pheromone, or light traps, could be used for other insects. Traps of a specific hue of yellow attract a broad spectrum of flying insects including whiteflies, thrips, aphids and leafhoppers.

5. Chemical Treatment[4]

Contact Applications. Many commonly used insecticides are wide-spectrum and persistent compounds. This can reduce the number of necessary treatments, but it can also be harmful to beneficial insects. Therefore, the greater the selectivity of the insecticide and the more rapid the biodegradation, the less harm to the beneficials. A high degree of selectivity, with separation in terms of time and space, will require a great deal of local knowledge about the insects in the nursery and their interaction. If repeated applications are needed, it is best to use different insecticides in successive treatments in order to avoid developing tolerance to any single chemical or related chemicals.

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3. The use of trade, firm, or corporation names in this report is for the information and convenience of the reader. Such usee does not constitute an official endorsement or approval by the U.S. Dept. of Agriculture of any product or service to the exclusion of others that may be suitable.

4. Because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency and the State of California, consult your local county agriculture commissioner to be sure the intended compound and use are still registered. Accurate, current, and cummulative annual information on pesticide use should be kept at all times.

A second approach would be to use a persistent, wide-spectrum insecticide. Beneficial insects would be harmed to a greater degree, but less precise knowledge of the interactions between the pest and its parasites and predators would be necessary.

Many pesticide formulations are registered for pests such as the melon aphid and the cabbage looper. However, it is doubtful if any of the plants grown at Joshua Tree National Monument will be on the labels. This will require extrapolation to plant type or group, or relying on a general registration, such as for nursery use on aphids. The county agricultural commissioner should be contacted to acquire assurance on current registration of any insecticide, its formulation, the method, time and frequency of application, and the necessary permits. The county agricultural commissioner is also a good source of information on compounds used locally and the possibility of pest resistance to any chemical proposed for use.

Systemic Application. With a drip irrigation system, it might be possible to make an insecticide application by installing a mechanism that would feed a systemic through the tubing system on a time-release basis. A granular systemic also might be incorporated in the potting mix in the upper few inches of soil. This might be soon leached away unless a time-release formulation is used. Systemics would have the advantage that they would not directly come into contact with parasites and predators. However, if prey imbibe a sublethal dose, predators may acquire a cumulative lethal dose. The predators would be lost while the pest would remain, free of some of the natural controls. Care should also be taken that systemics, as well as other formulations used, are not phytotoxic.

6. Biological and Other Formulations.

B.t. Most commercial formulations of *Bacillus thuringiensis* (B.t.) are registered for use against lepidoptera and Diptera. These could be useful against some pests in the nursery at Joshua Tree. *B.t.* var. *kurstaki*, a high-potency strain of *B.t.*, has been used against the cabbage looper in Ontario since 1972. Treated cole crops were as well protected as when treated with chemical insecticides (Jaques and Laing 1981). Canwell and Cantelo (1984) showed that *B.t.* var. *thuringiensis* was effective against the first- and second-instar larvae of the Colorado potato beetle. This potency was attributed to beta-exotoxin not found in products used for control of Lepidoptera. *B.t.* var. *san diego* also has been found to be effective against larvae and adults of the Coleoptera, but not Lepidoptera or Diptera (Herrnstadt *et al*. 1986). Toxicity against the Colorado potato beetle and the weevil, *Anthonomus grandis* Boheman, suggested commercial applications for this strain. Use against early instars would require close and accurate monitoring because use against older larvae and adults is less effective, and it is the later stages that cause most of the damage.

The absence of toxicity does not mean the absence of effect. Dilute solutions of *B.t.* extend the time of larval development and in so doing, enhance the possibility of parasitization or predation (Cantwell, Cantelo, and Cantwell 1986).

B.t. does not harm the beneficial parasites and predators. Therefore, a combination of B.t. applications along with the presence of egg parasites might be quite effective.

Neem Extracts. Neem (*Azadirachta indica* (A. Juss)) is a subtropical tree native to the arid areas of the Indian subcontinent, Southeast Asia and East Africa. Tetranortriterpenoides obtained from the seed are quite active as insect feeding deterrents, disruptants, of insect gorwth and development, or toxicants against a large variety of insect species and nematodes (Jacobson *et al*. 1983, Jacobson 1986). Liquid or dust formulations of ethanol extracts of the seeds have been shown to be nontoxic to warmblooded animals and nonmutagenic. Extract conetrations of 0.2 - 1% acted as a feeding inhibitor for a number of insects, including adults of the spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber), larvae and adults of the Colorado potato beetle (*Leptinotarsa decemlineata* (Say)), and larvae of the cabbage looper (*T. ni*). Extracts acted as feeding inhibitors, growth regulators and toxicants for larvae of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith).

Margosan-O^R is the only registered Neem insecticide in the United States and is labelled for use on non-food crops only (Olkowski 1987). It could provide an alternative to other materials for control of insects in the nursery.

Insecticidal Soaps. Insecticidal soap concentrate (50.5% fatty acid potassium soap) has been used to control the spotted popular aphid, *Aphis maculata* (Wilson and Moore 1986). Drip irrigation has the advantage of not washing the soap off.

Other. Urea plus ammonium nitrate solutions have been found to have synergistic insecticidal activity against the Colorado potato beetle and can be accepted in high doses as a foliar fertilizer by potato foliage. The results of using a stock fertilizer solution (5.35 gmol. urea + 5.35 gmol of ammonium nitrate per 1000 gm of solution) lead researchers to recommend using foliar fertilizer application to suppress low populations, to substitute for pesticides, and to mix with pesticides (Veverka & Oliberius 1987). This might have application for control of the threelined potato beetle, but might favor buildup of aphids.

7. Combination. None of the preceeding alternatives need be exclusive of the others. Even the Monitoring - No Action alternative is a precursor to the use of one or more of the other alternatives. By its definition IPM is a pest management system that utilizes all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury (Frisbie and Adkisson 1985). The basis for the system is applied ecology and requires knowledge of the hosts, pests, natural enemies, and the environment in which they exist. This is no small task even in a well-defined situation of a nursery that grows a limited number of plant species.

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APPENDIX

PEST BIOLOGIES

Lema trilineata (Olivier), three-lined potato beetle[1]

This beetle is about 6 mm in length, yellow, with three black stripes on the back. The larvae have the habit of forming a mass of granules of their own excrement which serves as a sheld over the greater part of their bodies. Pupation and overwintering occurs in the soil. There are two generations per year. Where potatoes are sprayed regularly for other pests this insect will not be found.

Lema nigrovittata Guerin, the striped datura beetle[2]

Although not found, this related species may occur in the nursery at Joshua Tree National Monument because all stages are found on Jimpson weed, which is apparently the native host, and also on burgmansia and cestrum. This beetle is 7-8 mm in length, black, portions of the prothorax and the elytra brown, the latter with two black longitudinal stripes. The appearance is similar to the threelined potato beetle. The eggs are pale orange and are laid in clusters of 4 to 20 on the leaves. The larvae are blackish and often covered with excrement and debris in the fashion of the threelined potato beetle. It is a Mexican species ranging into New Mexico, Arizona, and California, and is often mistaken for the western striped cucumber beetle, _Diabrotica trivittata_ (Mann.), which is smaller.

Trichobaris trinotata (Say), Potato stalk borer[2]

The larva feeds in the stems of several solanaceous plants and is occasionally destructive to eggplant and potato plantings. The adults are snout beetles, 3/16 inch in length, black with gray pubescence over the body except for three spots at the base of the wing covers and the head. Overwintering adults emerge from hibernation in the spring, feed on foliage, and lay eggs on the stems of potatoes or other hosts. On hatching the pale yellow larvae with brown heads burrow into the stalks, causing the greatest damage. By late July pupation occurs and transformation to adults takes place within the burrows where they remain until the following spring. Destruction of vines after harvest is of value in control.

Trichobaris mucorea (Lec.), Jimpson weed borer[2]

It is almost identical in coloration, but a little larger than the potato stalk borer, for which it has generally been mistaken. _T. compacta_ Casey also breeds in Jimson weed.

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1. Davidson, R. H. and L. M. Peairs. 1966. Insect pests of farm, garden, and orchard. John Wiley & Sons, NY. 675 p.
2. Essig, E. O. 1958. Insects of western North America. Macmillan Co., NY. 1050 p. (p. 464)

Aphis gossypii Glover, Cotton/melon aphid[1]

This aphid was collected only from coyote melon. However, this aphid is extremely polyphagous and therefore, this species is widely distributed in North America. It is considered the most important of several aphids that attack cotton and okra, and is also known as the melon aphid since it is a pest of melons and cucumbers, and less frequently, pumpkins, and squash. Jimpson weed and tender shoots of orange trees are hosts also. In general, aphids prefer young growth on well-fed plants, especially when nitrogen fertilizers have been used. Damage, caused by the nymphs and adults removing plant sap, results in the stunting of growth, curling of leaves, or death of tiny plants early in the season. Heavy feeding later in the summer causes the curled leaves to fall. These aphids also excrete honeydew which serves as a medium for the development of sooty fungus, a situation unlikely to occur under drip irrigation in a desert climate.

This common aphid varies from pale yellow to light or dark green, with dark leg joints, and black cornicles and eyes. In the Southwest, the melon aphid apears to omit the sexual forms and to hibernate in the winged and wingless stages on weeds and cultivated plants, and reproduces very rapidly as soon as conditions become favorable. Individuals become sexually mature in 4 to 10 days and large populations can appear suddenly in host fields and orchards (Kranz et al 1977). In the extreme South, only parthenogenetic females which give birth to young are found, with more than 50 generations often developing throughout the year. In the North, both sexes occur, and overwintering eggs hatch in the spring, all the progeny being wingless parthenogenic females. Repeat generations of the same type of individual occur through the summer, with occasional winged stages developing and flying to other areas. With the coming of cold weather, sexual forms are produced which mate, the females depositing the overwintering eggs.

Normally, control of aphids is required when their population density is low and their numbers are increasing at a maximum rate. As a popualtion becomes more dense, the increase rate decreases and, providing the plant does not collapse, the population stabilizes at a steady density (Krantz 1977). Even the most effective parasites can not increase rapidly enough to match the rapid phase of aphid buildup, and not until the population stabilizes can parasites overtake and bring about control. By then, in most circumstances, damage to the host will have occurred.

Aphids have numerous parasitoids and the melon aphid is no exception. Natural controls consist of aphid lions (lacewing larvae), syrphid fly larvae, lady beetles and other predators; insect parasites, of which the braconid wasps of the genus *Aphidius* are the most important; diseases; and hot, dry, summer weather. For many years the state insectary of California shipped great numbers of ladybird beetles to the Imperial Valley for suppression of aphid populations.

Prevention of buildup is desirable because this aphid is known to transmit 50 plant viruses. These are a greater threat to nursery production than the actual feeding damage.

Trichoplusia ni (Hubner), Cabbage looper[1]

Widely distributed in North America, this light green caterpillar, with a few white or pale yellow stripes and only three pair of prolegs, is often found feeding on cabbage and related plants. Its work is often mistaken for that of the imported cabbage butterfly, *Pieris rapae* (L.) Pieridae, and the two may be found on the same plants. The adult of the looper has dark brown, mottled forewings, each having a small silvery spot resembling a figure 8 near its center; the hind wings are almost uniformly light brown. The moths have a wingspread of slightly more than 1.5 inches.

The loopers winter in the pupal stage, the pupae being enclosed in flimsy silken cocoons attached to the food plants or to nearby objects. Moths emerge in the spring and deposit dome-shaped, pale green eggs on the host plants, cheifly at night. After hatching the destructive larval stage reaches full development in two to four weeks; pupation then occurs and in almost ten days the new adults emerge. Three or more generations are produced each season, depending on the latitude.

There is a high degree of natural control of this insect. Several parasites are usually numerous, a common species being the encyrtid wasp, *Copidosoma truncatellum* (Dalm.). Predators attack the larvae freely, and there is often a high mortality from a polyhedral virus disease. Insecticidal control can be secured by at least 10 insecticides, but the possibilities depend upon the crop to be treated. Pyrethrum insecticides are generally more effective for the looper than for other species of cabbage worms. This pest has developed resistance to some insecticides in some regions.

Gnathamitermes perplexus (Banks)[3]

Members of the genus are termites of the western semiarid to arid regions. They have the conspicuous habit of building extensive earthen covers over vegetation, posts and structures. Under certain circumstances they damage rangeland. They do not generally penetrate wood, but remove only a thin surface film of weathered material. Thinner vegetation, such as grass and small desert plants, is eaten away completely, leaving exoskeleton-like tubes with the general form of the consumed vegetation. They commonly tunnel into cow chips which, when coated with soil, are eventually completely replaced by an earthen replica.

G. perplexus is the common species throughout southern California, Nevada, Arizona and into Texas, and extends into Mexico at least as far as the state of Sinaloa on the west coast. This species is very variable and has been described under seven specific names. Workers may be white-headed or yellow-headed.

Colonies are centered under surface rocks, with foraging groups of functional workers, definitive workers, and soliers, occurring in cow chips, under surface boards and wood, and in workings on fence posts, stumps and similar items. There is a striking movement of eggs and small young from subsurface workings to underrock chambers, depending upon the temperature and moisture conditions. In the spring while the ground still retains residual moisture, and before the very hot days of summer, eggs and young are present in the underrock chambers during mid-day but are absent in the early morning and at night. When air temperatures rise, the eggs and small young will be absent at mid-day and early afternoon. As the soil grows dry, and air temperatures increase, no eggs or young can be located beneath surface rocks. The applicaion of water around surface rocks, however, will result in the reappearance of the young and eggs at surface workings. Similarly, rainfall will result in their reappearance.

Flights in Cochise County, Arizona, occurred in mid-June and early July and were associated with rainfall before and in several instances, during flight. Flights occurred in the early morning, in mid-afternoon, in the early evening and just after dark.

Many species of the Arizona fauna survive by adoption of subterranean habits; by utilizing the moisture contained in cow chips; by living in dead branches of live trees; or by adjusting activity cycles to favorable season of the year.

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3. Weesner, F. M. 1970. Termites of the Nearctic region, p. 477-525. In: Kumar Krishua and F. M. Weesner (ed.), Biology of termites Vol. II., Academic Press, NY. 643 p.

Some Commercial Sources of Biological Control Agents in California

The author is Gary W. Hickman, Farm Advisor, Cooperative Extension, San Joaquin County.

Biological control is the use of parasites, predators, and disease-causing organisms to help keep insect pests in check. Naturally occurring agents are continually at work in the environment. In some cases man has intervened in this process by releasing additional numbers of these agents in an attempt to improve the biological control of pests. However, limitations do exist with this type of program. For example, some biological control agents, such as the praying mantis, are general feeders, and are just as likely to capture and consume a beneficial insect as a crop-destroying pest. Others, such as the convergent lady beetle, cannot be expected to remain confined to the locale where they are released. Despite the limitations of some biological control agents, positive results have been obtained and interest in them continues. The purpose of this leaflet is to provide information on some commercial sources of parasites, predators, and pathogens available in California.

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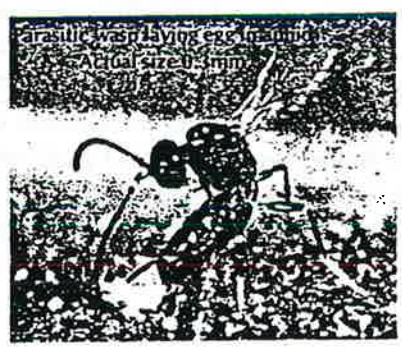
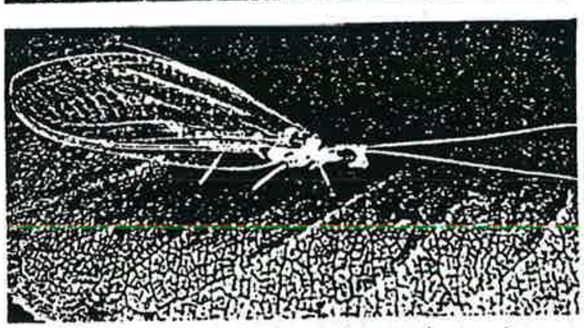
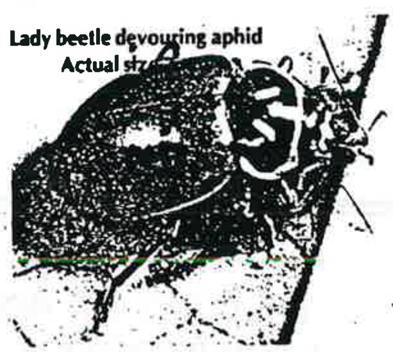
AGENTS

AP = Armyworm parasite - *Chelonus texanus*
BT = Caterpillar disease - *Bacillus thuringiensis* - (Biotrol, Dipel, Thuricide)
DM = Predatory mites - *Phytoseiulus persimilis*, and *Metaseiulus occidentalis* *Amblyseius californicus, A. hibisci*
GL = Green Lacewing - *Chrysopa carnea*
LB = Ladybugs (lady beetle) - *Hippodamia convergens*
MH = Black scale parasite - *Metaphycus helvolus*
MP = Mealybug destroyer - *Cryptolaemus montrouzieri*
MR = Fly parasite - *Muscidifurax raptor*
NV = Fly parasite - *Nasonia vitripennis*
PB = Pink bollworm parasite - *Microchelonus blackburni*
PM = Chinese praying mantis - Egg cases *Tenodera aridifolia sinensis*
PV = Fly parasite - *Pachycrepoideus vindemiae*
RS = Red scale parasite - *Aphytis melinus* and *Comperiella bifasciata*
SE = Fly parasite - *Spalangia endius*
TP = Tomato pinworm parasite - *Apanteles scutellaris*
TW = Parasitic wasp - *Trichogramma* spp
TZ = Fly parasite - *Tachinaephagus zealandicus*
WP = Whitefly parasite - *Encarsia formosa*







Photographs by Jack Kelly Clark

AGENTS	SOURCES
MP	Associates Insectary P.O. Box 969 Santa Paula, California 93060 (805) 525-7015
MR, SE	Beneficial Biosystems 1603 63rd Street Emeryville, California 94608 (415) 655-3928
GL, SE, TW	Beneficial Insects, Ltd. P.O. Box 154 Banta, California 95304 (209) 835-6158
NV, SE	Beneficial Insectary 245 Oakrun Road Oakrun, California 96069 (916) 472-3715
LB, PM	Bio-control Company P.O. Box 247 Cedar Ridge, California 95924 (916) 272-1997
RS (*Aphytis* only)	Foothill Agricultural Research, Inc. 510 W. Chase Drive Corona, California 91720 (714) 371-0120
LB	Fountain's Sierra Bug Company P.O. Box 114 Rough & Ready, California 95975 (916) 273-0513
LB, PM	Natural Pest Control 9397 Premier Way Sacramento, California 95826 (916) 362-2660
BT, LB, PM	Orcon Organic Control, Inc. 5132 Venice Boulevard Los Angeles, California 90019 (213) 937-7444
AP, BT, DM, GL, LB, MP, MR, PB, PM, PV, RS, SE, TP, TW, TZ, WP	Peaceful Valley Farms 11173 Peaceful Valley Road Nevada City, California 95959 (916) 265-5996
AP, DM, GL, LB, MP, MR, PB, PV, RS, SE, TP, TW, TZ	Rincon Vitova Insectaries, Inc. P.O. Box 95 Oak View, California 93022 (805) 643-5407
MR, PV, SE, TW, TZ	Spalding Laboratories Route 2 Box 737 Arroyo Grande, California 93420 (805) 489-5946
GL, LB, MR, PM, SE, TW, TZ	Unique Nursery 4640 Attawa Ave. Sacramento, California 95822 (916) 451-9929
BT, LB, PM	W. Atlee Burpee Company P.O. Box 748 Riverside, California 92502 (714) 689-1191
WP	White Fly Control Company P.O. Box 986 Milpitas, California 95035
BT, LB	Many nursery and discount stores.